DOCUMENT RESUME

ED 048 630 EA 003 337

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TITLE Toward a Model of School Operations: Relating Budgetary and Personnel Inputs to Indices of School Functioning. Working Paper.
PUB DATE 30 Oct 70
NOTE 27p.; Paper presented at Operations Research Society of America National Meeting (38th, Detroit, Michigan, October 28-30, 1970)

EDRS PRICE EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS Administrative Policy, *Average Daily Attendance, *Budgeting, Ethnic Distribution, *Models, *Personnel Policy, *School Holding Power, Statistical Analysis, Student Teacher Ratio

ABSTRACT

This paper attempts to develop models for the assessment of school functioning with the average percent daily attendance considered an index of school functioning. The data were obtained from 104 high schools, junior high schools, and elementary schools in the Boston Public School System. Multiple regression analysis, using the matrix of intercorrelations, accounted for 50 percent of the variance in the measure of school functioning. The sets of variables utilized in the analysis were designed to measure (1) school structure, (2) ethnic structure of the school neighborhood, and (3) administrative decisions relating to personnel and budgetary requirements. (Author/MLF)

WORKING PAPER

TOWARD A MODEL OF SCHOOL OPERATIONS:

Relating Budgetary and Personnel Inputs to Indices of School Functioning

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Presented at the 38th National Meeting
of the Operations Research Society of
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Detroit, Michigan

October 30, 1970

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INTRODUCTION

As quantitative methods begin to be applied to the assessment of school functioning, it is instructive to experiment with the development of models based on information obtained from a variety of more or less readily available sources. The present paper is an attempt to develop such models. If the data generated by these models can be shown to be relatively isomorphous to our assumptions and expectations about reality, then this model can be used to describe reality. If not, then the areas where discrepancies exist between the model and reality can be identified and modified; if necessary, the model can be rejected.

We begin with the assumption that the functioning of a school can be described, at least in part, by three component facets: (1) structure of the school itself, (2) the ethnic

structure of the neighborhood in which the school resides, and (3) by administrative decisions relating to the personnel and budgetary requirements of the school. We then test this assumption by observing the goodness of fit between the data we have observed which seem to measure the components enumerated above, and the model which describes our assumptions.

Finally we revise the model where necessary, and retest the revised model with respect to our assumptions.

THE SAMPLE

The models discussed in this paper are based on the population of 104 high schools, junior high schools (or middle schools), and elementary schools in the Boston Public School System which were identified by inspecting the Budget: General School Purposes, 1968 and the Annual Statistics of the Boston Public Schools: School Year 1967-1968. Both these documents are published by the School Committee of the City of Boston. Schools designed for what is known generically as "special education," such as education of the deaf or the blind, were excluded from this analysis.

The units of analysis was the individual school. Missing data, to be discussed below, reduced the number of observations for one or two variables in some cases, but at least 90 observations were available for each variable in every case.

THE DATA

Index of School Functioning

The index taken to be a measure of school functioning is the Average Daily Percent Attendance for each school in the school year 1967-1968. The Average Daily Percent Attendance in 1967-68 was 89.6.

Several assumptions are basic to the use of percent attendance as an index of school functioning. It can be assumed that not all of the some 9,400 students who are absent because of illness or other unavoidable causes. Indeed in 1968 Boston spent approximately $447,000 for attendance services which are defined as "those activities which have as their primary purpose the promotion and improvement of children's attendance at school through enforcement of compulsory attendance laws and other means"[1]. Forty-seven full time personnel were employed to provide these services.

In industry absenteeism is often regarded as a barometer of employee morale. Industries with high daily absence rates often ascribe these absences as much to employee dissatisfaction with working conditions as to illness or other causes.

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[1]Budget, General School Purposes, 1968 of the School Committee of the City of Boston.

The same may be true of schools. Students may well be absenting themselves from school not because of the lure of more exciting alternatives - the street corner has little to recommend it except perhaps a feeling of freedom and companionship - but because conditions within the schools are driving them away.

Speculation aside, however, the crux of the issue is that no matter how good its facilities, or how well qualified its staff, the school cannot fulfill its intended function of exposing its students to desirable learning experiences without the physical presence of its students. All other things being equal (they're not, of course), the extent to which students are absent is the extent to which their education suffers.

Finally, the use of percent attendance as an indicator of school function is appealing because its use permits comparison across many schools of different sizes and types. It is a statistic which is easily calculated and understood and it is available for virtually every public school in the United States.

School Structure

Several variables were explored for inclusion in this set. These included the sex ratio of the school, whether or not the school restricted enrollment in any way such as academic versus vocational, and school size. Considerations of sample size and a desire to keep the models simple lead us to employ a procedure known as dummy variable coding to construct this set.

Two variables were created, High School and Elementary School. If a school was a high school, the High School variable was coded "1", if not it was coded "0". The same procedure was followed for the Elementary School variable. If a school was a junior high or middle school, zeroes were entered for both High School and Elementary School. In this way the effects of all three elements in the trichotomy are represented in the model. (Jacob Cohen in his article "Multiple Regression as a General Data Analytic System"[2] has described this method and its uses and advantages in some detail.)

[2] Psychological Bulletin, 70, pp. 426-443

Ethnicity

The ethnicity data were obtained from data collected in the 1960 U.S. Census. These data were originally aggregated by block within census tracts. From this base the data were subsequently transformed to represent the ethnicity of precincts in Boston by investigators at Harvard University. We then calculated the weighted mean of the ethnic measurements for each school or district by estimating the proportion of any precinct which lay within the boundaries of each school or school district.

The determination of the ethnicity of a school district was a relatively crude procedure because the school or school district's boundaries did not match well with the boundaries of the precincts. In addition, some of the schools, especially the high schools, have considerable cross registration under Boston's "Open Enrollment" policy. Indeed the select high schools, such as Boston Latin School, accept students from the entire city. A further difficulty is that many of the neighborhoods in Boston seem to have changed considerably in their ethnic composition from 1960 to 1967 producing an indeterminate but definite decay in the reliability of the 1960 census figures.

The ethnicity variables used were: Ethnic Concentration, Foreign Ancestry, and Irish Ancestry. The Ethnic Concentration variable is the percent of residents of the largest non-

black foreign ethnic group in a district. This variable indicates the extent to which a non-black ethnic group dominates a precinct. The Ethnic Concentration variable correlates highly with two ethnicity variables not used in the models and can be taken as an index of them. Inspection of Table 1 reveals that Ethnic Concentration correlated +.83 with the percent of people of Italian Ancestry in the district and -.70 with the percent of residents in the district who were non-white. Hence the Ethnic Concentration variable contrasts the tight Italian neighborhoods in Boston with those neighborhoods composed of a majority of black residents.

Insert Table 1 about here

Foreign Ancestry is the percent of the residents in the district who were born, or whose parents were born, in a foreign country. Many of Boston's immigrant population came from countries as diverse as Ireland, Italy, China, Greece, Cuba, Portugal, Canada, and Russia, to name only a few. A precinct with a high Foreign Ancestry score thus tends to have many first and second generation immigrants, often from a variety of countries.

Irish Ancestry is the percent of residents in the district who were born in Ireland or whose parents were born there. This variable was included because Boston is known as an "Irish City" - its schools, its politics, and its civil services are dominated by those of Irish Ancestry. For this

Table 1.

Matrix of Intercorrelations Among Variables
Considered for Use in Models in School Functioning.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	1
1. High School	1.00											
2. Elementary School	-.51	1.00										
3. Ethnic Concentration	-.11	-.04	1.00									
4. Foreign Ancestry	-.13	.01	.70	1.00								
5. Irish Ancestry	-.02	.08	-.15	.10	1.00							
6. Percent Non-white Residents in District	-.01	.05	-.70	-.82	-.39	1.00						
7. Italian Ancestry	-.13	.01	.83	.49	-.35	-.44	1.00					
8. Expenditures for Salaries per Registered Student	.18	.05	.07	-.03	-.33	-.03	.22	1.00				
9. Expenditures for Supplies per Registered Student	.23	-.21	-.04	-.10	-.20	-.04	.04	.67	1.00			
10. Number of Administrators per 100 Teachers	.47	-.62	.28	.08	-.15	-.05	.19	.06	.11	1.00		
11. Number of Teachers per 100 Students	.02	.17	-.04	-.08	-.27	.00	.12	.89	.65	-.22	1.00	
12. Average Daily percent Attendance	-.45	.57	.06	.21	.22	-.18	.07	-.16	-.23	-.49	-.11	1.0

reason it is of interest to explore the relationship of the proportion of Irish residents in a district to our measure of school functioning.

As can be expected, these three variables are not uncorrelated with each other (see Table 1), but they seemed to be expressing different aspects of the ethnic structure of a school district, so it was decided to include them all in the model. Several other ethnic variables were considered for inclusion in this set but were rejected for various reasons. Among these were Italian Ancestry, Canadian Ancestry, Russian Ancestry, and the percent of non-white residents in a district. This latter variable is of considerable theoretical and practical importance in the study of the functioning of schools in any large city, but, unfortunately, data were missing for nearly half the school districts in Boston.

Administrative Discretionary Variables

These variables were derived from the Annual Statistics of the Boston Public Schools, 1967-1968 and from the Budget, General School Purposes, 1968 of the School Committee of the City of Boston. Four variables were used to represent the Administrative Discretionary set. These were: Expenditures for Salaries per Registered Student, Expenditures for Supplies per Registered Student, Number of Administrators per 100 Teachers, and Number of Teachers per 100 Registered Students. These

variables are termed "Administrative Discretionary" because the allocation of personnel and funds to each school is, in theory at least, under the direct control of and at the discretion of the central school administration and the school committee.

Expenditures for Salaries per Registered Student was obtained by dividing the number of registered students in each school by the aggregate salary budget for that school. In Boston, provisional and permanent teachers receive a salary increase every year for a maximum of ten years. In addition, salary increments are awarded to teachers who earn advanced degrees. Since teachers with greater longevity and more experience have higher salaries than newer, less experienced teachers, this variable is an index of the general experience level of the staff of the school.

Expenditures for Supplies per Registered Student was similarly obtained by dividing the total supplies budget allocated to each school by the number of students registered in the school. In the Boston Schools there is a basic supplies per capita allocation to each school. In addition there are special programs such as advanced work classes and enrichment programs which provide extra supplies to schools with such programs. This variable, then, is an index of the amount expended for such special programs existing in a given school.

The Number of Administrators per 100 Teachers index was obtained by dividing the number of administrators in each school by the number of teachers in that school and multiplying by 100. In the Boston schools an "administrator" includes all Head Masters, Principals, Assistant Head Masters, Assistant Principals, Department Heads, Research Assistants, Guidance Counselors, and Shop Foremen. In brief this variable is an index of the number of professional, administrative, supervisory, and ancillary personnel available in each school.

The teacher-pupil ratio of each school was determined by dividing the number of teachers in each school by the number of students. This ratio was multiplied by 100 to produce the Number of Teachers per 100 Registered Students index. The higher this index, the smaller the class size. If the teacher-pupil ratio of a school increases, the amount of individual attention available for each student is increased.

Method of Analysis

The matrix of product moment intercorrelation coefficients, allowing for missing data, was calculated for the variables considered for inclusion in the model. Each coefficient is based on those variables in each case which had data present for both variables being correlated. If data points were absent for either or both variables being correlated the two data points were dropped from the calculation. This method makes maximum use of available data without altering the data base in any way. Most of the missing data were in the ethnic variable set, though some were missing in the discretionary set as well.

General linear models, with parameters fitted by the usual least squares procedures were constructed using the matrix of intercorrelations. Routine multiple regression programs were used for the statistical calculations. The major index of the precision of a model was the coefficient of determination, or R^2, which can be interpreted as the proportion of the variance of the dependent variable explained or predicted by the model.

F-ratios for the significance of the loss of precision as sets of variables were deleted from the model were used to determine whether sets of variables could be dropped without significantly reducing the precision of the model.

Results

The means, standard deviations and number of observations of the variables included in the models to be discussed below are presented in Table 2.

Insert Table 2 about here

The results of the first set of models are presented in Table 3 and are exemplified in Figure 1.

Insert Table 3 about here

Insert Figure 1 about here

In the Boston Public Schools in 1967-1968 half (50 percent) of the variance in our measure of school functioning could be explained by the full model using sets of variables designed to measure the school structure, the ethnic characteristics of the neighborhood, and administrative discretion. The last column of Table 3 gives the standardized regression coefficients for the variables of the full model, with the R^2 at the foot of the column. In this full model the most powerful variables are in the administrative discretion set, with the directions of the beta coefficients indicating that schools with fewer teachers per 100 students and with fewer administrators per 100 teachers but with better paid teachers function best.

Table 2.

Means, Standard Deviations, and Number of Observations, Used in Calculating the Matrix of Intercorrelations.

Var. No.	Set Variable Name	Mean	Standard Deviation
	School Structure		
1.	High School (= 1 if High School, = 0 Otherwise)	.16	.37
2.	Elementary School (= 1 if Elementary School, = 0 Otherwise)	.57	.49
	Ethnicity		
3.	Ethnic Concentration	17.50%	11.93%
4.	Foreign Ancestry	44.94%	12.46%
5.	Irish Ancestry	10.48%	7.16%
	Administrative Discretion		
8.	Expenditures for Salaries per Registered Student	$476.60	$145.58
9.	Expenditures for Supplies per Registered Student	$ 24.39	$ 9.26
10.	Number of Administrators per 100 Teachers	15.16	4.59
11.	Number of Teachers per 100 Registered Students	4.72	1.36
	Index of School Functioning		
12.	Average Daily Percent Attendance	89.60%	3.70%
	Number of Observations		
	Maximum 104		
	Minimum 90		

Table 3.

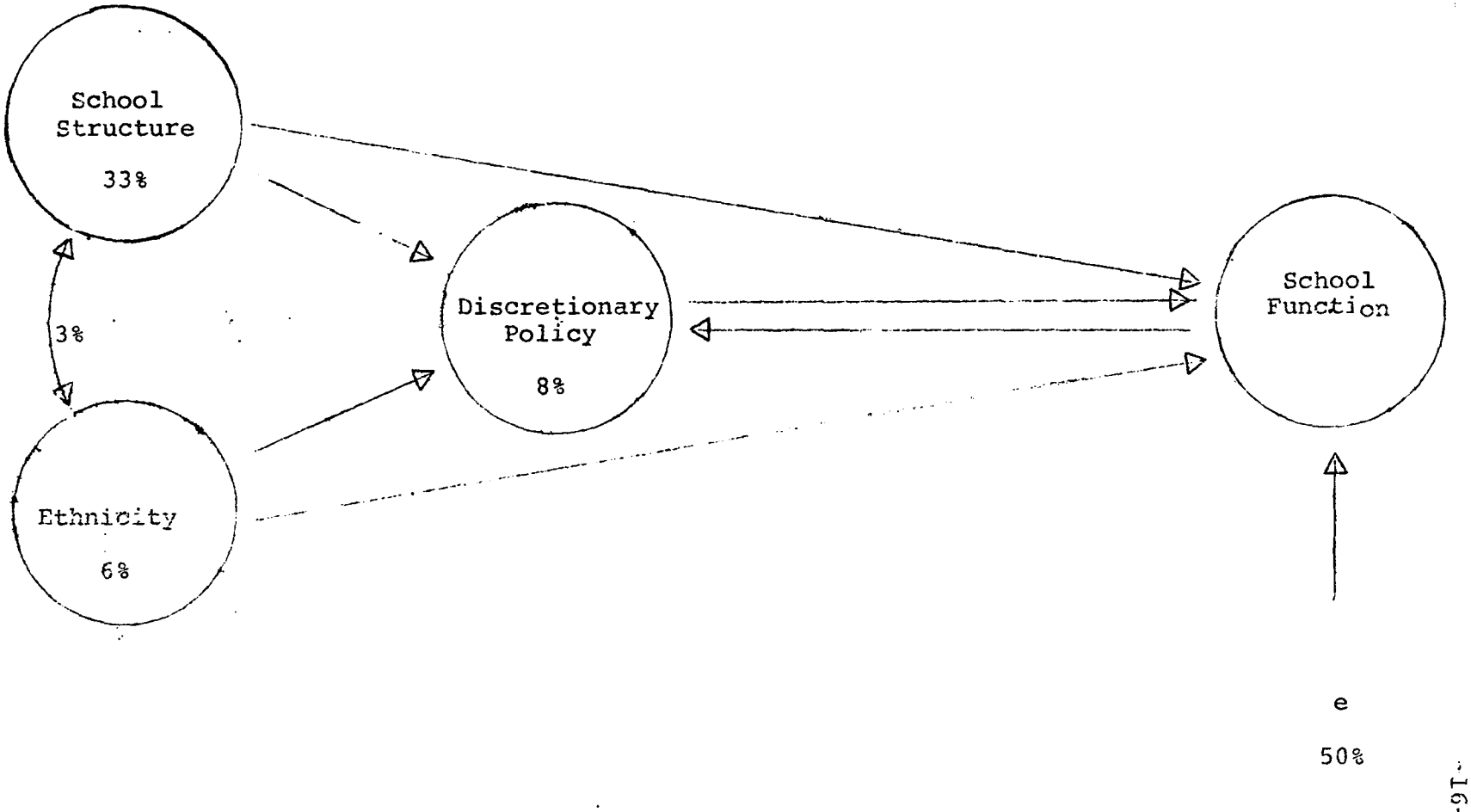
Standard Partial Regression Coefficients and Proportion of Variance Accounted for in Several Models of School Functioning

	Standard Partial Regression Coefficients						
	S	E	D	S & E	S & D	E & D	S&E&D
I. SCHOOL STRUCTURE							
High School	-.22			-.20	-.18		-.14
Elementary School	.46			.45	.37		.36
II. ETHNICITY							
Ethnic Concentration		-.10		-.08		.11	-.00
Foreign Ancestry		.26		.22		.14	.18
Irish Ancestry		.18		.15		.12	.10
III. ADMINISTRATIVE DISCRETION							
Salaries per Registered Student			.55		.43	.52	.42
Supplies per Registered Student			-.08		.08	-.05	.09
Administrators per 100 Teachers			-.66		-.36	-.68	-.36
Teachers per 100 Registered Students			-.69		-.68	-.64	-.64
PERCENT OF VARIANCE IN INDEX OF SCHOOL Functioning Explained by Independent Variables in Model. (R^2)	.36	.09	.33	.42	.45	.39	.50

KEY:
S = School structure
E = Ethnicity
D = Administrative Discretion

Figure 1

Assumed Implicit Paths of Causation Underlying the Model



The school structure variables indicate that elementary schools function better than do junior high schools or than do high schools in terms of our index of school functioning, percent of attendance. In general, elementary schools have a higher percent of attendance than junior high schools or high schools. High schools have a lower percent of attendance than either junior high schools or elementary schools.

The ethnic variables, as measured in the present study, were less important than the school structure or than the administrative discretionary variables. The direction of the standardized regression coefficients indicates that schools in districts with a high proportion of residents of Irish descent or in districts dominated by residents of foreign ancestry functioned better than did schools in districts with low proportions of residents of Irish or general foreign descent. The contrast between tight ethnic neighborhoods (usually Italian) and the more heterogeneous neighborhoods, often black, as exemplified in the Ethnic Concentration variable, did not seem to make much difference in the model. This is not to be taken as indicating that black neighborhoods had the same level of functioning of their schools as did white neighborhoods. In other analyses, not reported here, of those districts in which the percent of non-white residents was known, we found that this variable acting alone as a representative of the ethnic set of variables, accounted for about the same proportion of variance in percent attendance as the set of variables used in this model.

The results of analyses of variance and F-ratio tests on the significance of the loss of precision of the model with the deletion of sets of variables indicated that the deletion of the ethnic variables from the full model did not decrease the precision of the model significantly. However deletion of either the school structure set or the administrative discretion set did significantly reduce the precision of the model. On the other hand the models built using only one set of variables, were all significantly better than the null model, that model which considers only mean daily percent attendance with no additional information. Hence the ethnic variables do carry considerable information. In these single set models, the school structure set accounts for 36 percent of the variance; the ethnic set accounts for 9 percent; and the discretionary set accounts for 33 percent.

The implicit causal model we assumed was that the school structure and the ethnic structure of the neighborhood were independent of each other, but both were prior to the administrative discretionary set. We assume that administrative decisions of a discretionary nature are based at least in part on the type of school under consideration and in part on the requirements of the constituents of the school as reflected by their ethnic background. The effects of all three are reflected in the functioning of the school. Figure 1 illustrates this implicit causal model. Here 33 percent of the variance in school

functioning is attributed to school structure, 6 percent is attributed to neighborhood ethnicity, with 3 percent of the variance common to both sets of variables. This overlap in variance may be due to ethnic differences in the proportion of school age children in elementary and in high schools. For example, the Catholic ethnic groups in Boston have greater access to non-public schools than non-Catholic ethnic groups. Moreover, Catholic high school students in Boston are slightly more likely to attend non-public schools than are Catholic elementary school students.

The addition of the administrative discretionary set of variables to the school structure and ethnicity set which are considered to be increases the percent of variance accounted for in percent attendance by 8 percent. There is considerable overlap between school structure and administrative discretion variables; in the implicit model, this was allocated to school structure. For example, elementary school teachers tend to be paid less than high school teachers; this variance is attributed to the structure of the school rather than to policy decisions of the school administration.

Examination of t-tests for the significance of the regression coefficients suggested that three of the nine variables could be dropped from the model; these were Irish Ancestry, Ethnic Concentration, and Supplier per Registered Student. Thus, of the ethnicity variables, both Irish Ancestry and Ethnic Concentration could be dropped. Of the administrative discretionary variables, the Supplies per Registered Student variable could be dropped. The standard partial regression weights for

the remaining variables do not change in direction or proportionality nor do they change materially in size when the three variables are dropped from the original model.

The results of deleting these three variables are presented in Table 4. The results are now presented in terms of the raw regression weights of the new model. This enables us to discuss the variables in the model in terms of their original units of measurement. The full model now accounts for 48 percent of the variance instead of the 50 percent from the nine variable model.

Insert Table 4 about here

However the decrease in precision is not significant and, in fact, the decrease from nine to six parameters which need to be estimated considerably improves the model. Structure alone, now accounts for 36 percent of the variance, ethnicity alone accounts for 4 percent. Structure and ethnicity together account for 38 percent of the variance in school functioning.

Examination of the raw weights given in equation (1) of Table 4 indicate that when we hold everything else in the model constant, knowledge of the fact that a school is an elementary school increases the predicted average daily percent attendance for that school by about 2.6 percent over the predicted percent attendance in the average junior high school. Conversely, everything else being equal, knowledge of the fact that a school is a high school decreases the predicted average daily percent of attendance for that school by 1.3 percent less than the pre-

Table 4
Examples of General and Specific Models of School Functioning

General Model

(1) $\hat{Y} = A - B_1(X_1) + B_2(X_2) + B_4(X_4) + B_5(X_5) - B_8(X_8) - B_{10}(X_{10}) - B_{11}(X_{11}) \pm e$

$= A - 1.34(X_1) + 2.59(X_2) + 0.06(X_4) + 0.01(X_5) - 0.31(X_8) - 1.63(X_{10}) - 1.63(X_{11}) \pm e$

A = Y intercept
B_i = Partial Regression Coefficient for Variable i
X_1 = 1 if a High School, 0 if not
X_2 = 1 if an Elementary School, 0 if not
X_4 = Percent of Foreign Ancestry
X_8 = Salaries per 100 Registered Students
X_{10} = Administrators per 100 Teachers
X_{11} = Teachers per 100 Students
$\hat{Y}$ = Predicted Value of Percent Attendance
e = Standard Error of Estimate (2.6)

Specific Models

(2) Expected Values for all Students

$89.5 \pm 2.6 = 93.20 - 1.34(0.16) + 2.59(0.57) + 0.06(44.94) + 0.01(476.60) - .31(15.16) - 1.63(4.72) \pm e$

(3) Expected Values for High Schools

$86.9 \pm 2.6 = 93.20 - 1.34(1.00) + 2.59(0.00) + 0.06(44.94) + 0.01(476.60) - .31(15.16) - 1.63(4.72) \pm e$

(4) Expected Value for Jr. High Schools

$88.3 \pm 2.6 = 93.20 - 1.34(0.00) + 2.59(0.00) + 0.06(44.94) + 0.01(476.60) - .31(15.16) - 1.63(4.72) \pm e$

(5) Expected Value for Elementary Schools

$90.8 \pm 2.6 = 93.20 - 1.34(0.00) + 2.59(1.00) + 0.06(44.94) + 0.01(476.60) - .31(15.16) - 1.63(4.72) \pm e$

(6) Expected Value if X_8 was Increased \$100.00
X_{10} was Decreased by 3, and X_{11} was Decreased by 1

$93.1 \pm 2.6 = 93.20 - 1.34(0.16) + 2.59(0.57) + 0.06(44.94) + 0.01(576.60) - .31(12.16) - 1.63(3.72) \pm e$

dicted percent attendance in the average junior high school. Finally, the predicted average daily percent attendance for any junior high school will be about 2.6 percent less than the percent of attendance in the average elementary school and about 1.3 percent greater than the percent of attendance in the average high school. Thus it can be seen that the functioning of junior high schools in terms of percent of attendance, is midway between that of high schools and elementary schools, but it is more like that of high school than that of elementary schools. These findings are exemplified using mean values as the constants in Equation (3), Equation (4), and Equation (5) of Table 4.

DISCUSSION

It should be emphasized that the present analysis makes many assumptions, some of which are clearly tenuous. The primary assumption is that Average Percent Daily Attendance is an adequate index of school functioning. Certainly it is an index of school functioning, but the question of its adequacy as such an index remains to be determined. Secondly, the very crude indices used of the ethnic status of the neighborhood mean that this set of variables did not have an adequate chance to show what they could do. Indeed we might expect that the half of the variance left unexplained might be reduced considerably with better ethnicity measures. The addition of indices of the socioeconomic status of the residents in each school district and the proportion of children residing in each district who are enrolled in non-public schools would also be expected to increase the precision of the model considerably.

The present models have demonstrated that a considerable proportion, about half, of the variance of an index of school functioning can be accounted for by a model containing six to nine variables. The Administrative Discretionary set of variables, when acting alone in a model can account for about a third of this variance. It is our opinion that the most realistic estimate of the amount of influence such administrative policy changes could have is the difference between the

full model and the two set model using school structure and ethnicity of the neighborhood. This two set model accounts for 38 percent of the variance, the addition of administrative variables increases this to 48 percent. Thus policy considerations can affect about 10 percent of the variance in school functioning over and above that variance already determined by school structure and neighborhood characteristics.

The direction of influence of the administrative discretionary variables indicates that schools with fewer teachers per 100 students and fewer administrators per 100 teachers, but with better paid teachers are functioning better than schools in which these conditions tend to be reversed. One interpretation of these findings is that when a school is beset by problems there is a tendency for older, more experienced, teachers to request transfers out of that school. Because of their seniority in the system, they are granted these transfers. To fill the gap created by this loss, the administration hires newer, less experienced teachers. These teachers are immediately faced with problems, especially problems related to maintaining order and discipline in the classroom. Because of their inexperience these new teachers are not equipped to deal with such problems. Hence more teachers are required in the school to supervise and control the students and more administrators are required to supervise and assist the teachers. To keep the lid on the pot, these additional personnel are provided by the administration.

Evaluation of the general model presented in Equation (1) of Table 4 suggests an alternative approach to the one described above. The more experienced teachers should be induced to remain in the problem school. This would require difficult policy decisions on the part of the administration. When vacancies occur experienced personnel should be recruited for these schools. When it becomes necessary to hire new personnel they would then not only have the assistance of the building administration but could also draw on the experience of the veteran teachers in the building.

Substitution of hypothetical values into the model [Table 4, Equation (6)] lends some evidence to support this line of reasoning. If the experience level of teachers in Boston were raised a salary equivalent of $100 per student more than it is now; and if the number of administrators per 100 teachers were three fewer than now; and if the number of teachers per hundred students were one fewer than the current average, the model predicts that the average daily percent attendance would increase from 89.5 percent to 93.2 percent. With an increase of experienced teachers, indicated by greatly increased salaries, school functioning would be improved considerably. In this example, mean salaries for school personnel would be about $14,000, but class size could be increased to about 26 students per teacher.

Considerable caution should be used in any application of this, or similar models. For example, a naive interpretation of Table 4 would indicate that if all the administrators were removed from a school, reducing the Administrators to Teacher ratio to zero, the index of school functioning would be improved, on the average, from 89.5 percent to 94.2 percent. We doubt that the model would hold for such extreme values in this or any of the variables used. It is necessary to remember that the model was developed on the schools of the Boston Public School system for 1967-68 and can only reflect the range of variation of the variables in that population.

Finally, the causal directions of the effects of the variables in this model have not been established, and can only be established through further research and policy experimentation.

However the present approach of using quantified variables from a variety of sources to develop models of school functioning offers promise of raising interesting questions and providing guidance for the development of policies with a reasonable prospect of having a beneficial effect on future school functioning.